

CLAIMS

What is claimed is:

1. An apparatus for switching electrical current, comprising:
 - a) an ohmically isolated island comprised of material having a band gap, wherein the island is sufficiently large such that electron energy levels within the island are separated by less than 100 meV;
 - b) a source contact;
 - c) a first tunnel junction barrier disposed between the island and the source contact, wherein the first tunnel junction barrier has a thickness and cross sectional area selected such that a first tunnel junction formed by the source contact, the first tunnel junction barrier and the island has a resistance less than a quantum resistance;
 - d) a drain contact;
 - e) a second tunnel junction barrier disposed between the island and the drain contact, wherein the second tunnel junction barrier has a thickness and cross sectional area selected such that a second tunnel junction formed by the drain contact, the second tunnel junction barrier and the island has a resistance less than the quantum resistance;
 - f) a gate electrode capacitively coupled to the island.
2. The apparatus of claim 1 wherein the island comprises semiconductor material selected from the group consisting of silicon and germanium.
3. The apparatus of claim 1 wherein the first tunnel junction and second tunnel junction each have resistances less than 10 KOhms.

1 4. The apparatus of claim 1 wherein the first tunnel junction and second tunnel junction
2 each have resistances less than 1 KOhms.

1 5. The apparatus of claim 1 wherein the first tunnel junction and second tunnel junction
2 each have resistances less than 100 Ohms.

1 6. The apparatus of claim 1 wherein the first tunnel junction barrier and second tunnel
2 junction barrier each have a thickness less than 24 Angstroms and a cross sectional area
3 greater than 0.04 microns².

1 7. The apparatus of claim 1 wherein the first tunnel junction barrier and second tunnel
2 junction barrier each have a thickness less than 18 Angstroms and a cross sectional area
3 greater than 0.01 microns².

1 8. The apparatus of claim 1 wherein the first tunnel junction barrier and second tunnel
2 junction barrier each have a thickness less than 12 Angstroms and a cross sectional area
3 greater than 0.0025 microns².

1 9. The apparatus of claim 1 wherein the first and second tunnel junction barriers comprise
2 insulator material selected from the group consisting of silicon oxide and aluminum oxide

1 10. The apparatus of claim 1 further comprising a gate insulating layer disposed between the
2 gate electrode and the island.

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1 11. The apparatus of claim 10 wherein a channel length between the first tunnel junction
2 and second tunnel junction is in the range of 0.02-0.2 microns.

1 12. A circuit, comprising:

2 a pair of tunnel junctions, each having a resistance less than or equal to approximately a
3 quantum resistance, separated by an island formed of a material having a non-uniform density
4 of energy states, each of the tunnel junctions being formed by the interconnection of the island
5 with a respective one of a pair of conductors through a tunnel junction barrier; and
6 a gate electrode capacitively coupled to the island.

1 13. The circuit of claim 12 wherein the island is formed of a superconductor material.

1 14. The circuit of claim 12 wherein the island is formed of a semiconductor material.

1 15. The circuit of claim 14 wherein the semiconductor material comprises silicon.

1 16. The circuit of claim 14 wherein the semiconductor material comprises germanium.

1 17. The circuit of claim 12 wherein the tunnel junction barriers are formed of an oxide of a
2 material from which the conductors are made.

1 18. The circuit of claim 17 wherein the gate electrode is made of the same material as the
2 conductors.

1 19. The circuit of claim 12 wherein the tunnel junction barriers are formed of an oxide of a
2 material from which the island is made.

1 20. The circuit of claim 12 wherein the tunnel junction barriers are formed of a material
2 different from that of which the island is made and different from that of which the conductors
3 are made.

1 21. The circuit of claim 12 wherein the island is formed of an undoped material.

1 22. The circuit of claim 12 wherein the non-uniform density of energy states comprises at
2 least one region that contains available energy states adjacent to at least one region that does
3 not contain any available energy states.

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1 23. A method, comprising forming a conduction path between a pair of tunnel junctions each
2 having a resistance less than or equal to approximately a quantum resistance by shifting
3 energy states of an island formed of a material having a non-uniform density of such energy
4 states, the island being disposed between the tunnel junctions.

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1 24. The method of claim 23 wherein the energy states of the island are shifted by application
2 or removal of a voltage through an electrode capacitively coupled to the island.

1 25. The method of claim 24 further comprising passing a current through the conduction path
2 via electrodes coupled to the tunnel junctions.